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DRAWINGS ATTACHED

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(54) REPEATING SURGICAL STAPLER

(71) We, CODMAN & SHURTLEFF, INC., a Corporation organised under the laws of the State of Massachusetts, located at Randolph, Massachusetts, United States of America, do hereby declare the invention, for which we pray that a patent may be granted, to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to staplers and relates more particularly to miniature staplers of the type used by surgeons for joining together living tissues and to exchangeable cartridges for use with such staples.

The instant invention has for its principal object the provision of a stapler that will fasten at each actuation a single miniature staple having two legs and a crown connecting the legs. The stapler of the present invention permits the surgeon to rapidly connect two or more layers of tissue by applying a plurality of staplers, one staple at a time.

Complicated surgical operations on blood vessels, bronchi, large pulmonary blood vessels, intestines, and so forth require rapid suturing, a problem of increasing concern to the surgeon as the size of the vessel decreases. The stapler of the present invention enables the surgeon to quickly apply with precision a single staple or a plurality of staples in a minimum period of time.

A multiple stapler capable of successively applying a plurality of miniature staples in rapid sequence is disclosed in U.S. Patent No. 3,225,996. The stapler and cartridge of the present invention, however, function differently and provide the surgeon with a considerable advantage in that the tip of the stapler is small and affords excellent visibility at the very point that the surgeon needs good visibility during the surgical stapling procedure.

It is an object of the invention, therefore, to provide a surgical stapler that is accurate, foolproof, and reliable in use with a narrow point to permit good visibility of the working area. Another object of this invention is

to provide a stapler that will at each actuation sequentially apply a series of single, miniature staples.

A further object of the invention is to provide a staple cartridge that is disposable and interchangeable and is adapted to being loaded mechanically with a plurality of miniature staples.

The present invention provides a surgical stapler for use in fastening at each actuation a single miniature staple having two legs and a crown connecting the legs, comprising in combination (a) a pair of forceps including two arms movable relative to each other; (b) a cartridge holder positioned between the two arms on the forceps; (c) a cartridge removable and emplaceable in a predetermined position on the holder, the cartridge having at its forward ends opposing straight parallel shoulders perpendicular to the longitudinal axis of the holder and said cartridge containing a plurality of miniature staples each having two legs and a connecting crown, the staples being in parallel alignment within a centrally-located channel extending from one end of the cartridge to the parallel shoulders; the first staple in the series being in contact with the shoulders and suspended between the walls of the channel; the crown of all other staples in the series being in frictional contact with the top surface of the channel and the free ends of each staple pointing in a direction perpendicular to the longitudinal axis of the cartridge; (d) a staple pusher slidably movable within the channel in registry with the staples; (e) means mounted on the holder for forcing the pusher and the staples to the forward end of the channel so that the first staple is forced into contact with the shoulders; (f) an anvil, having means for inwardly clinching said free ends, at one end of one of the arms and adjacent the position of the free ends of the legs of the suspended staple when the cartridge is emplaced; and (g) a driver element at one end of the other arm and adjacent to the position occu-

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pied by the crown of the first staple when the cartridge is emplaced and movable arcuately toward and from the anvil and operable to abut and to press against the crown thereby to drive the first staple in a straight movement towards the anvil.

Preferably, the means for forcing the pusher and the staples to the forward end of the channel comprises a spring biased member slidably mounted on the holder for continuously urging the pusher against the staples.

Advantageously, there is provided a projection on the forward end of the cartridge extending above the top surface of the cartridge; the forward edge of the projection being displaced from the inner walls of the opposite straight parallel shoulders at a distance equal to the thickness of a staple and in alignment therewith.

There may also be provided, two opposite longitudinal grooves, located at opposite sides of the cartridge, and preferably terminating at the forward end of the cartridge in a shoulder. The opposite sides of the cartridge that extend beyond the longitudinal grooves are advantageously serrated.

Preferably, there is also provided, a rectangular opening in the bottom surface of the centrally located channel the width of the opening being equal to the width of the channel and in registry therewith.

The driver element preferably has a width less than the width of a staple and a thickness greater than the thickness of a staple.

The invention will now be described in greater detail by way of example only with reference to the accompanying drawings wherein:—

Figure 1 is a side elevation partially in section of a stapler according to the present invention;

Figure 2 is an inverted plan view thereof, viewed along the line 2—2 of Figure 1;

Figure 3 is a plan section along the line 3—3 of Figure 1;

Figure 4 is an end view as seen when viewed in the direction of line 4—4 of Figure 1, parts omitted for clearness;

Figure 5 is a vertical cross-section taken along the line 5—5 of Figure 1;

Figure 6 is a plan view of the stapler anvil on an enlarged scale;

Figure 7 is a cross-section thereof taken along line 7—7 of Figure 6;

Figure 8 is an exploded perspective view of the cartridge holder and associated slide;

Figure 9 is a vertical cross-section taken on line 9—9 of Figure 2;

Figure 10 is a perspective of a staple cartridge viewed from the dispensing end;

Figure 11 is an inverted perspective view of the cartridge shown in Figure 10;

Figure 12 is an exploded perspective of

the cartridge as viewed from the feeding end and shows the staple pusher;

Figure 13 is a plan of the cartridge as drawn in Figures 10, 11, and 12;

Figure 14 shows the side view thereof;

Figure 15 is the cartridge view of Figure 14 looking at the dispensing end;

Figure 16 is a vertical cross-section taken on the line 16—16 of Figure 14;

Figure 17 shows a longitudinal cross-section taken on the line 17—17 of Figure 13 with staples in place;

Figure 18 shows a plan section taken along the line 18—18 of Figure 17;

Figure 19 is a view of the first staple in the cartridge illustrated in Figure 17;

Figure 20 is a fragmented portion of the cartridge shown in Figure 10, with the driver, staple, and anvil in position;

Figure 21 is a modification of the stapler illustrated in Figure 1, with a cartridge in position for loading;

Figure 22 is an edge view thereof;

Figure 23 is a vertical cross-section on an enlarged scale taken along the line 23—23 of Figure 21;

Figure 24 is a detailed perspective of a spring used in the modified stapler shown in Figures 21 and 22;

Figure 25 is an enlarged plan view of a cartridge, some elements of which have been exaggerated in size for clearness of operation;

Figure 26 is a cross-section thereof taken on the line 26—26 of Figure 27, and showing the driver and anvil in position for driving a staple; and,

Figure 27 is an end view as seen when viewed in the direction of line 27—27 of Figure 26.

Three Leaf Stapler

Figures 1, 2, 3, and 20 illustrate a medical stapler generally indicated at 21 comprising a pair of forceps with a driver arm 22 terminating in a driver 23 and an anvil arm 24 terminating in an anvil 25. These arms 22, 24 are movable toward and from each other for driving a staple 26, that is held in a cartridge 28 above the anvil 25. Both arms are provided on the exterior with knurling 30 for easier manual grasping. A cartridge holder 32 is secured to the driver arm 22 by a leaf spring 34.

Each of the arms 22 and 24 is resilient and forms a leaf spring, the arms in their normal position being spread apart as shown in Figure 1.

As best shown in Figures 3, 8, and 9, a limit stop 36 bridges a slide 38, the function of which will be described below, and is secured to the cartridge holder 32. The upward movement of the upper arm 22 relative to the cartridge holder 32 is limited by the head 40 of a screw 42 which extends

through a notch 44 in the stop 36. By this means the driver arm 22 is pre-tensioned.

The lower arm 24 of the forceps 21 terminates in an anvil 25 provided with two clinching grooves 27 and 29.

Referring now to Figures 3 and 8—11, the cartridge holder 32 is constructed with two prongs 45 and 47 spaced to frictionally engage two lateral grooves 49 and 51 on the staple cartridge 28. The slide 38 is held against the upper surface of the cartridge holder 32 by the shoulders 53 and 55 on the limit stop 36, and movement of the slide is limited to a direction parallel to the longitudinal axis of the cartridge holder by the projection 52, which slides between the prongs 45 and 47. The slide is normally retained in its forward position, illustrated in Figure 1, by the tension of the spring 54 which holds the shoulders 57 and 59 of the slide 38 against the back surface of the limit stop 36.

The Staple Cartridge

As best shown in Figures 10—19, the staple cartridge, which may be molded of plastic, is constructed with a centrally-located pusher channel 60 that extends from the back end 52 of the cartridge to opposite parallel staple grooves 63 and 65 at the forward (dispensing) end thereof; the parallel grooves being formed by the side walls of the channel 60 and the walls of the parallel shoulders 77 and 79. Said shoulders are perpendicular to the longitudinal axis of the cartridge and the channel. The cartridge is formed with an integral center piece 64 (Figure 18) at the forward end of the channel, the face 66 of which is disposed between the grooves 63 and 65 and is parallel with the inner surfaces of the shoulders 77 and 79 being displaced therefrom by a distance equal to the thickness of a single staple. The thickness of a staple is determined by the diameter of the wire used to form the staple, i.e., about 6—9 mils. Located within the channel of the cartridge is a plurality of miniature staples, each having two legs 67 and 69 connected by a crown 68 (see Figure 19). As best shown in Figure 17, the series of staples within the channel are in parallel alignment with the crown of each staple in frictional contact with the top surface 70 of the channel, the free ends 71 and 73 of each staple being in frictional contact with the tip of guides 61 and 72 and pointing in a direction perpendicular to the longitudinal axis of the cartridge.

A U-shaped staple pusher 74 is provided having a cross-section that conforms with the cross-section of the staples and the channel. The pusher is slidably movable within the channel in the direction of the longitudinal axis of the cartridge and is in registry with the series of staples contained therein. Move-

ment of the staple pusher toward the forward end of the cartridge forces the series of staples forward so that the first staple 26 of the series is forced against the outer walls 77 and 79 of the parallel grooves.

A projection 80 extending from the top surface of the cartridge has a forward face 84 which is parallel to the shoulders 77 and 79 and in vertical alignment with the first staple 26. The projection 80 engages the driver 23 as shown in Figure 9 and serves the dual function of retaining the cartridge on the cartridge holder against the pressure of the spring 54, and aligning the cartridge and the staple 26 with the driver and anvil. It is preferred that guiding means for the staples and driver are provided and hence vertical surfaces 81 and 82 at the forward end of the cartridge are provided spaced apart a distance slightly greater than the width of the driver 23. These surfaces 81 and 82 prevent lateral movement of the driver as it descends to drive the staple.

Staple alignment markers 83 and 85 may be provided on the forward edges of the cartridge to assist the surgeon in lining up the instrument and cartridge with the tissue to be stapled. As shown in the drawings, serrated gripping surfaces 86 and 88 may be provided at the rear of the cartridge where obstruction of the surgeon's view is not a problem.

Regarding the staple sizes that may be used where minimization is important, the following are examples of desirable sizes:

	2 mm. Staple	3 mm. Staple
Diameter of wire (thickness of staple)	.006	.009
Length of crown 68 (width of staple)	.080	.120
Length of leg 69 (height of staple)	.100	.140

Each cartridge 28 may be loaded manually, or preferably with the aid of a loading machine. To facilitate machine loading of the cartridges with a plurality of staples and to permit visual inspection of the staples when they are all loaded, an opening 90 may be provided on the underside 92 of the cartridge. The width of the opening 90 corresponds with the width of the channel 60. Each cartridge 28 containing its staples will be sterilized in any suitable manner and will be kept packaged in sterilized condition until used.

Operation of the Stapler

In using the stapler the nurse or surgeon removes the sterile cartridge from its sealed container grasping it by the serrated edges 86 and 88 and sliding it onto the cartridge holder in the direction of the arrow (Figure 1).

As the cartridge is forced onto the holder 32 (See Fig. 9), the staple pusher 74 is forced against the projection 52 of slide 38 and moves it in the direction of the arrow 5 against the tension of the spring 54. Simultaneously, the driver 23 is forced upward by the inclined surface of the projection 80 at the forward end of the cartridge, returning to its normal spread-apart position as indicated in Figure 9 after the edges 84 of the projection has passed the end of the driver. The cartridge may then be released, as it will be held in a fixed position by the tension of the spring 54 which forces the edge 84 of the projection 80 against the driver 23. Angular movement of the cartridge with respect to the cartridge holder is prevented by the prongs 45 and 47 of the holder which engage the longitudinal grooves 49 and 51 on the cartridge.

The lower arm or anvil spring 24 is weaker than the upper arm pretensioned driver spring 22, so that when the surgeon presses the two arms 22 and 24 toward each other, the anvil 25 will first move upward to a position that is shown in dotted lines in Figure 9. This enables the surgeon to grasp the tissue between the anvil and the lower surface of the cartridge before driving the staple.

Further pressure will force the driver downwardly in a wide arc against the tension of the spring 34. As the driver descends, it bears against the face 66 of the center piece 64 and is directed in the plane of the grooves 63 and 65, driving the first staple 26 out of the cartridge, through the tissue, and clinching it on the anvil 25. When the staple has been driven and the surgeon releases the applied pressure, the arms return to their spread-apart position, indicated by solid lines in Figure 9, and the spring 54 moves the slide 38 and its terminal projection 52 forward advancing the staple pusher 74 within the channel 60. The movement of the series of staples as the staple pusher advances within the channel will be understood from Figures 25—27. Each staple of the series is in frictional contact with the top surface 70 and the side walls of the channel 60. As the driver 23 clears the top surface 70 of the channel, the next staple in the series is pushed between the top surface of the channel 70 and the upper surface of the center piece 64 against the shoulders 77 and 79 beneath the driver 23 in position for driving. It will be apparent from the above that during the use of this instrument, there will always be a staple suspended between the driver and anvil until the supply of staples in the cartridge has been used up.

Ring Handle Stapler

In Figures 21 and 22 is shown a modified stapling instrument of the scissor's type, which differs from the medical stapler described

above in the shape of the forceps and accordingly in the location of the fulcrum 120. It will be noted that in most other respects the multiple stapler dispenser of Figures 21 and 22 resembles that of Figures 1—7 and functions in a similar manner. For the parts that are alike, there will therefore be used herein the identical reference numerals, while merely corresponding parts have different prefix numerals.

The modified medical stapler illustrated comprises a scissor's type of forceps with a driver arm 122 terminating in a driver 23 and an anvil arm 124 terminating in an anvil 25. Finger grips 102 and 104 at the opposite ends of the arms 122 and 124 facilitate precise positioning and operation of the stapler deep within a body cavity. These arms 122, 124 are movable toward and from each other about the fulcrum 120 for driving a staple that is held in a cartridge 28 above the anvil 25.

A cartridge holder 32 is secured to the driver arm 122 by a spring 134.

As best shown in Figure 23, a limit stop 136 is secured to the cartridge holder 32 and bridges a slide 38, the function of which has been described above. The upward movement of the upper arm 122 relative to the cartridge holder 32 is limited by the stop 136. The tension of the spring 134 normally retains the driver and cartridge holder in the spread-apart position shown in the drawings. By this means the driver arm 122 is pretensioned. The stop 136 also limits the distance between the cartridge holder 32 and the driver 23 and assures that the cartridge will be retained on the holder by the pressure of the driver against the face 84 of the cartridge projection 80.

In the modified stapler, as in the instrument described previously, the cartridge holder 32 is constructed with two prongs 45 and 47 spaced to frictionally engage the lateral grooves 49 and 51 on staple cartridge 28. The slide 38 is held against the upper surface of the cartridge holder 32 by the shoulders 153 and 155 on the limit stop 136, and movement of the slide is limited to a direction parallel to the longitudinal axis of the cartridge holder by the projection 52, which slides between the prongs 45 and 47. The slide is normally retained in its forward position, illustrated in Figure 22, by the tension of the spring 54.

Cartridges for use with the stapler modified as shown in Figures 21 and 22 are identified in all respects with the cartridge described above and illustrated in Figures 10—20. As previously indicated, the cartridge is preferably disposable and may be made of plastic or other inexpensive material that lends itself to being sterilized, such as, for instance plastic known under the Trade Mark DELRIN.

The operation of the modified instrument

is similar to that of the one previously described. A sterile staple cartridge is slipped on the cartridge holder, past the driver, and released. The spring-biased slide will hold the face 84 of the cartridge projection 80 against the inside surface of the driver, properly positioning the cartridge on the holder with the first staple directly under the driver. The surgeon then grasp the tissue to be stapled between the anvil and the lower surface of the cartridge and drives the staple by pressure on the finger grips closing the forceps and driving the staple from the cartridge.

The spring 134 causes the driver to return to the position illustrated in Figures 21 and 23 when the surgeon releases the pressure on the finger grips, and a new staple is advanced within the cartridge by the staple pusher as described above.

20 WHAT WE CLAIM IS:—

1. A surgical stapler for use in fastening at each actuation a single miniature staple having two legs and a crown connecting the legs, comprising in combination (a) a pair of forceps including two arms movable relative to each other; (b) a cartridge holder positioned between the two arms on the forceps; (c) a cartridge removable and emplaceable in a predetermined position on the holder, the cartridge having at its forward ends opposing straight parallel shoulders perpendicular to the longitudinal axis of the holder and said cartridge containing a plurality of miniature staples each having two legs and a connecting crown, the staples being in parallel alignment within a centrally-located channel extending from one end of the cartridge to the parallel shoulders; the first staple in the series being in contact with the shoulders and suspended between the walls of the channel; the crown of all other staples in the series being in frictional contact with the top surface of the channel and the free ends of each staple pointing in a direction perpendicular to the longitudinal axis of the cartridge; (d) a staple pusher slidably movable within the channel in registry with the staples; (e) means mounted on the holder for forcing the pusher and the staples to the forward end of the channel so that the first staple is forced into contact with the shoulders; (f) an anvil, having means for inwardly clinching said free ends, at one end of one of the arms and adjacent the position of the free ends of the legs of the suspended staple when the cartridge is emplaced; and (g) a driver element at one end of the other

arm and adjacent to the position occupied by the crown of the first staple when the cartridge is emplaced and movable arcuately toward and from the anvil and operable to abut and to press against the crown thereby to drive the first staple in a straight movement towards the anvil.

2. A stapler as claimed in claim 1, wherein the means for forcing the pusher and the staples to the forward end of the channel comprises a spring biased member slidably mounted on the holder for continuously urging the pusher against the staples.

3. A stapler as claimed in claims 1 or 2, wherein a projection is provided on the forward end of the cartridge extending above the top surface of the cartridge, the forward edge of the projection being displaced from the inner walls of the opposite straight parallel shoulders at a distance equal to the thickness of a staple and in alignment therewith.

4. A stapler as claimed in any one of claims 1 to 3, wherein two opposite longitudinal grooves are located at opposite sides of the cartridge.

5. A stapler as claimed in claim 4, wherein longitudinal grooves terminate at the forward end of the cartridge in a shoulder.

6. A stapler as claimed in claims 4 or 5, wherein the opposite sides of the cartridge that extend beyond the longitudinal grooves are serrated.

7. A stapler as claimed in any one of claims 1 to 6, wherein there is provided, a rectangular opening in the bottom surface of the centrally located channel the width of said opening being equal to the width of the channel and in registry therewith.

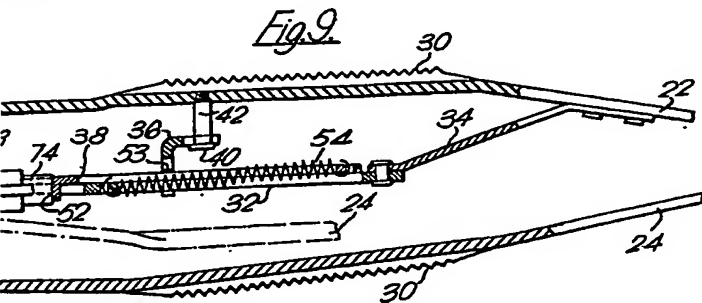
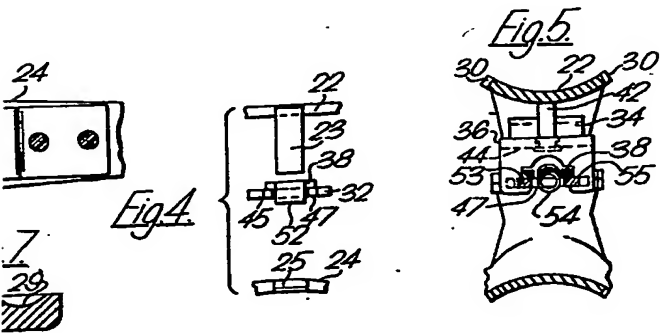
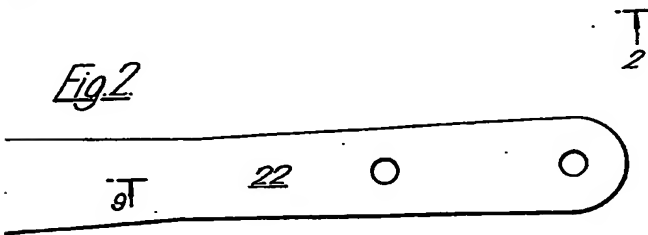
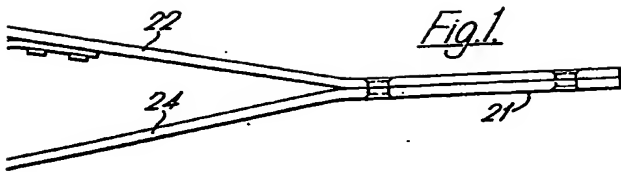
8. A stapler as claimed in any one of claims 1 to 7, wherein the driver element has a width less than the width of a staple and a thickness greater than the thickness of a staple.

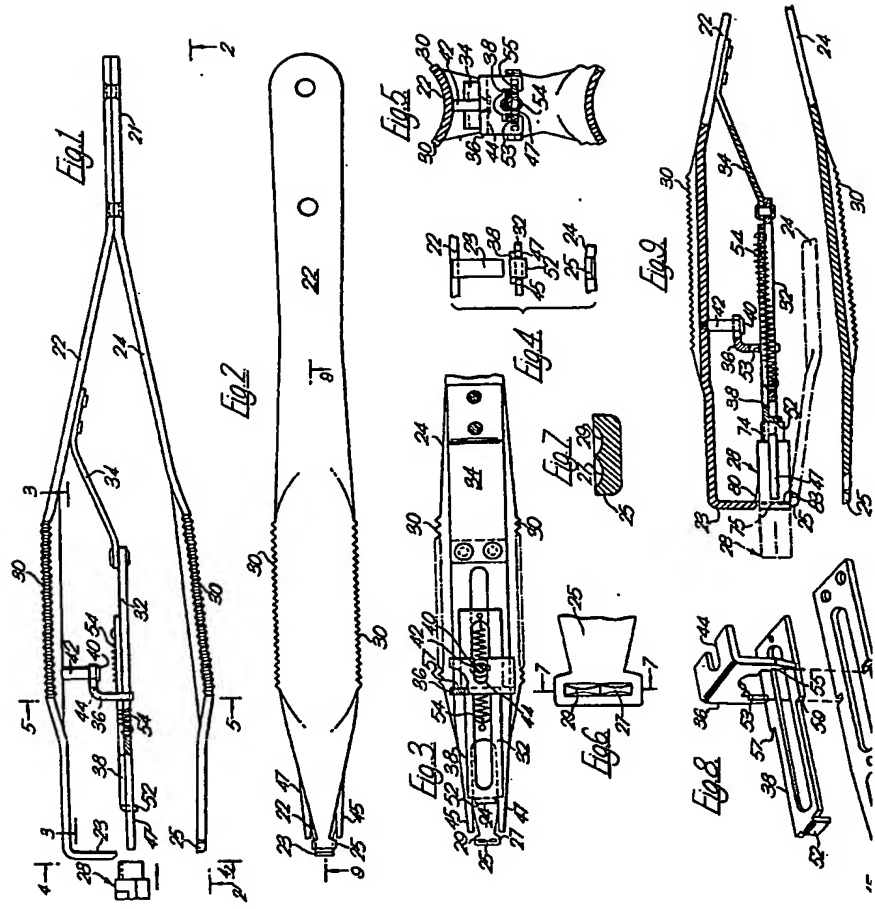
9. A stapler as claimed in any one of claims 1 to 8, wherein the forceps are provided with ring handles.

10. A stapler substantially as hereinbefore described with reference to the accompanying drawings.

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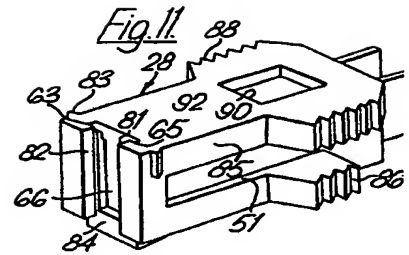
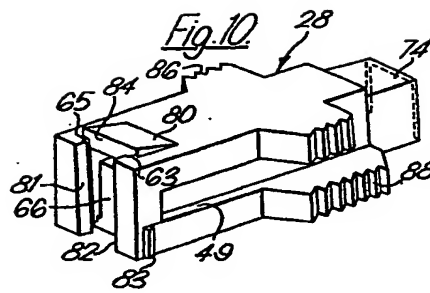


Fig. 21.

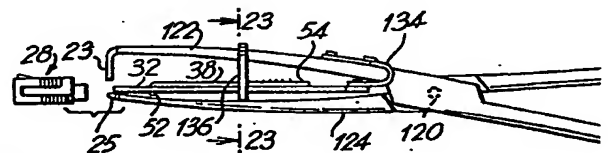
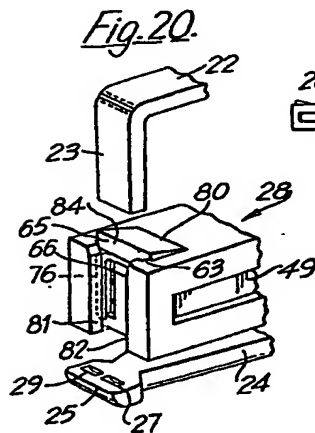
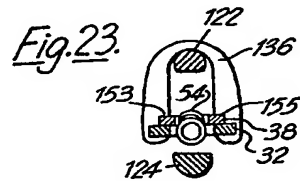
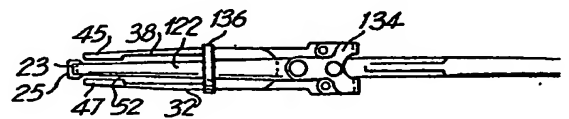
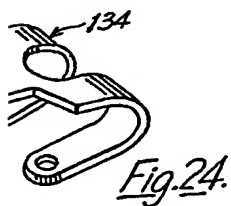
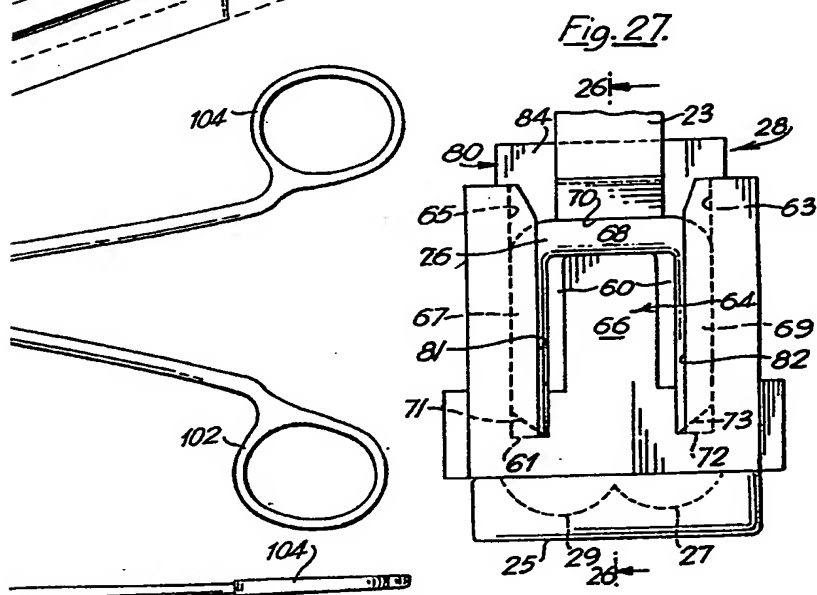
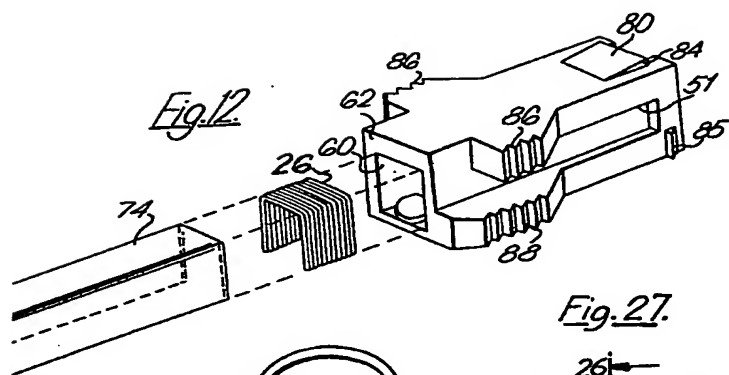
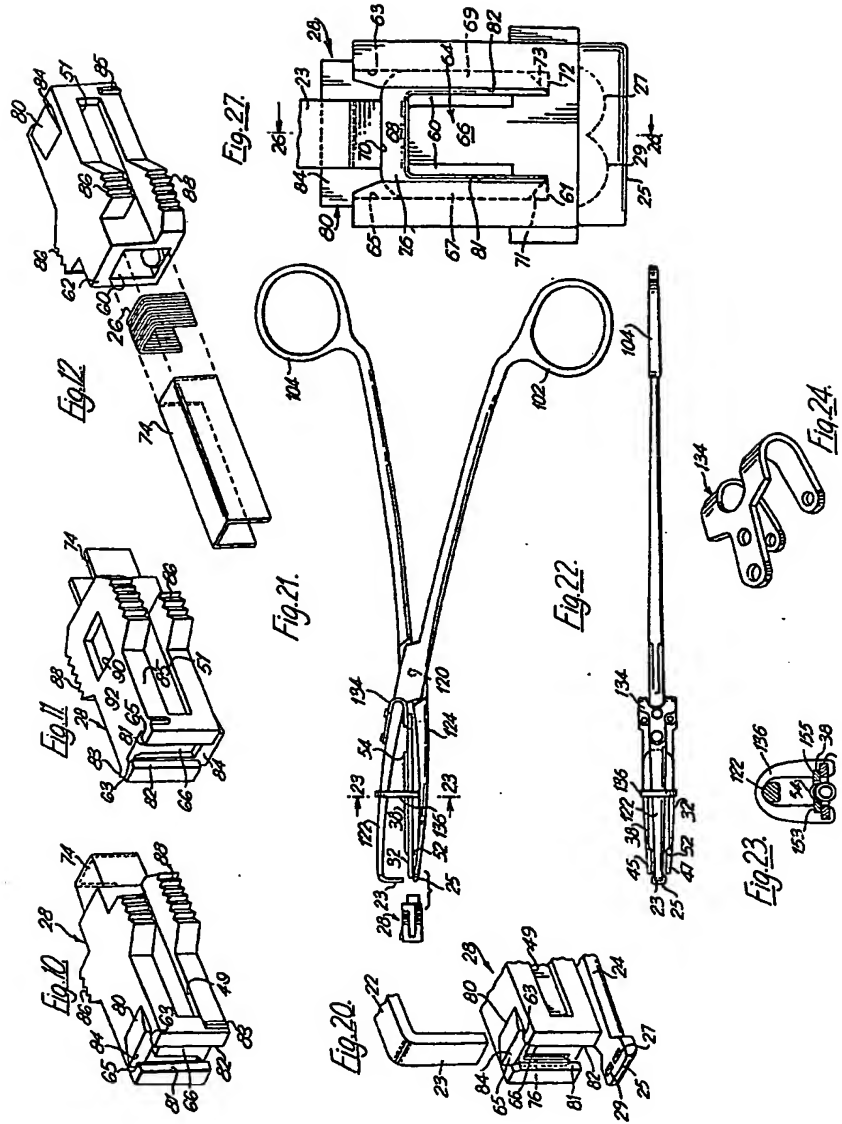


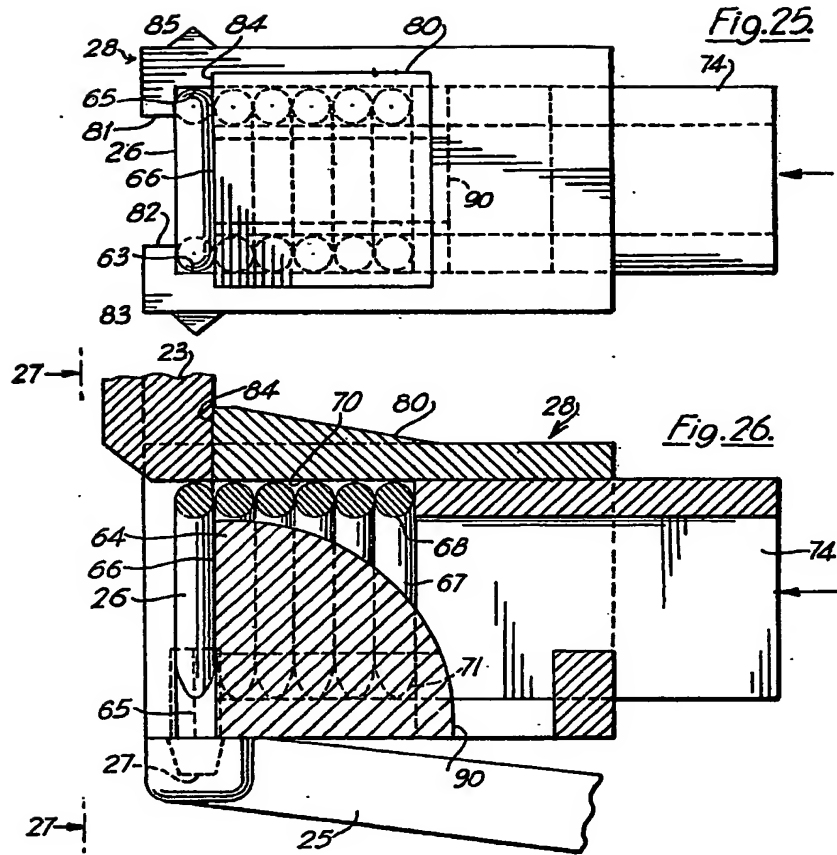
Fig. 22.



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